OBSERVATIONS UPON THE NEWER BOTANY.[1]

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THE LEAF A LIGHT-RELATED ORGAN.

UNDER life relations it may be an advantage to some that an instance be stated even though it be in brief terms. Let us take the leaf as it is, one of the three vegetative organs.

The leaf is divided into three parts—the stalk, stipules, and blade. Furthermore, the blade is made up of the framework, the pulp, and the skin that envelops all and holds the parts together. It has been stated that the leaf is a light-related organ, and it will be to the point to consider this relationship.

It is the pulp that interests us in considering the leaf as related to the light, and this is the soft portion lying between the upper and lower skin, and supported by the framework. It consists of minute cells somewhat loosely placed.

It is now that the microscope lends valuable assistance, for by it it is seen that the cells consist of three parts, the wall or sac, the liquid, and the green granular contents.

It is these minute masses of protoplasm, colored green by chlorophyll that interest us in a study of the light relation, for it is in these that the energy of motion is transformed into energy of position—kinetic into potential.

Within these chlorophyll granules the energy of the vibrating rays of the sun splits up the molecules of water, coming from the soil through the roots and stem, and those of the carbonic dioxide from the atmosphere driving off a portion of the oxygen. Thus, if we should have six groups of the carbon dioxide molecules ($6\ CO_2$) and five of water ($5\ H_2O$) there might be a separation of twelve atoms of oxygen, and the union

[1] Remarks following a paper upon Botany for the Secondary Schools, by Dr. J. M. Coulter, before the Natural Science Section of the National Educational Association, Washington, D. C., July 1898.

of the remaining portion would give a molecule of starch ($C_6 H_{10} O_5$). This is food making reduced to its simplest terms, and the chlorophyll granules that float in the semi-liquid plasma are the centers of synthesis of organic compounds.

Each starch granule, whether of wheat, potato, sago, or rice, represents a potential energy that may remain unnoticed until the occasion for oxygen to unite again with the elements in the compound when it ceases to exist as starch, and with the liberation of sensible energy carbon dioxide and water result. In other words, the sun's force raises the inorganic compounds to a higher plane by deoxidation and union, and from that plane they may fall back, yielding, in the descent, an energy that physicists tell us is equal to that by which it was raised.

In considering the leaves in their relationship to the sun and the whole realm of life upon the earth, it is evident we are face to face with the most potent of vital activities, and are getting at the heart of the forces that move the world.

We might well, with much solemnity, approach the subject that lies before us, for the green leaf, as it stands upon its supporting twig, is a minute laboratory in which a noiseless chemist is constructing compounds that possess a potency peculiarly their own.

With these facts in mind it needs be a very heedless child who will not be impressed with the worth of the wealth of greenness that is met with in the living vegetable fabric that is woven with sunlight to clothe the otherwise barren earth.

From this central thought concerning light relations of plant foliage there are a thousand starting points for study, and time permits of but the briefest mention of a few. Many plants have no green color, but doubtless prosper. These are the parasites, plants that have long ago formed the habit of gaining their nourishment at secondhand, and from those who do their own work of synthesis. The golden-threaded dodder, the sickly-hued mistletoe are of this class. They form no exception in the true sense, for they steal instead of labor for their living.

The mushroom, toadstools, molds, and mildews are other

low forms of plants that live upon organic matter similar to the more exalted flower-bearing parasites.

There are many plants that, while making their own food, are seemingly without green. This is only a seeming, for beneath all the bright color there is an abundance of the chlorophyll, which may be as readily extracted from the showy coleus leaf as from the green grass.

There is a long list of questions that naturally arise in the thoughtful mind as to the behavior of plants in relation to the sunshine. To illustrate this we will go out in imagination into the woods and clearing.

A BIT OF FIELD WORK.

It is possible that a little study like the following may be made. Let me draw the outline of the problem that is to be investigated. Imagine, if you will, you are standing upon a slope of land facing the north, that the sun may not blind your eyes. To the right is a wood lot, with its oak, hickory, chestnut, birch, and other trees, standing neighborly, with arms interlocked, not too closely for comfort, and through the branches the broken shafts of light reach the shrubbery and herbaceous vegetation beneath. There are the alders, huckleberries, and their close of kin, the Virginia creeper, running upon the ground and over the smaller trees in the vicinity of a sleepy rivulet bordered by skunk cabbage and jack-in-the-pulpit. Where it is not quite so marshy the ground view of the woods is delightfully obscured by a luxuriant growth of the cinnamon fern, for it is midsummer.

To the left is a similar piece of young wood lot, not a primeval forest in either instance, and here the wild grape clings to the young maple, and the poison sumach may be lurking in the low land. In front of you, however, lies a strip twenty rods wide, where the woodman's axe has done its destructive work, and the clumps of small growth you see are the sprouts from the maple and other stumps. This is the second season from the time of clearing.

Have you the picture before you? A rectangle of vegetation stretching down to the rivulet that is lost under the direct rays of the summer sun and then on up the slope beyond, all framed in by right lines of forest trees and grateful shadows. If you have located the clearing from my brief outline you are ready to enter in and possess it botanically. If such a piece of land, even though it be but a single acre, is close at hand, you have a treatise upon vegetable ecology and physiology that contains no ends of treasures. Not that it bears any long list of species, but that it does possess the various conditions that, taken in connection with the border land, are more interesting than books, for it is the living volume, that vitalized cyclopædia of facts and the suggestion of principles, that make plant analysis seem tame and useless, save as it may help to catch the convenient handle to hold the subject that is undergoing some delightful transformation.

Let that clearing be your field of study day by day. When the days are long and the heat is intense make notes, and with specimens there gathered retreat into the shade of the wood lot upon either side. Compare the port of the sun-kissed, and it may be sunburned, herb with that of its shaded neighbor of the same species. Both were once alike, but the axe of the woodsman has let in the full sun upon the one, with drying effect upon the soil surroundings. One bears or attempts to bear the burden and heat of the day while the other is nursed in broken sunshine and a moister soil.

The Osmunda in the sun has its fronds strict and upright, the pinnæ uplifted and twisted to lessen the direct exposure. In the shade the habit is that of some other species, with the fronds gracefully curved outward, and the delicate pinnæ so placed as to catch every broken shaft of the sunlight that penetrates the tree tops. The ferns in the open are bleached, while those in the shade are deep green; the former are tough and the latter delicate.

Every plant in the clearing that has survived the ordeal of the exposure is a study of adaptation, the reason for the change

in some instances not being upon the surface; but this only adds to the interest that is centered in the clearing and its surroundings.

This is the newer botany. It is not yet in the books, and, in one sense, never can be. It inheres in the plants themselves, and any attempt to lodge it elsewhere must needs be futile. I trust each teacher of the science of botany may find a field for study in the sense of the clearing above briefly outlined.

It may be more convenient for some student and teacher, and one needs to be both to be the latter, to have a garden patch where plants may be asked various questions. If it is in the line above indicated, a shading total or partial may be easily arranged. For example, a half shade may be provided by placing frames of lath upon stakes. The frames may be made, for a few cents, by nailing ordinary carpenter's laths to cross laths at the ends with a single lath interwoven through the middle. If half shading is desired, let the vacant spaces between the laths be equal to the width of the laths. Under such a shading ordinary plants, like bush beans, lettuce, etc., may be grown, and the variations in time of germination, size of plant, of leaf, time of blooming, size of fruit, longevity, etc., can all be studied with no small amount of interest and profit at a minimum of expense.

Should you like to make a record of the difference in thickness, for example, between the exposed and shaded leaves it can be done by actual measurement, but there is another way not mentioned in the books. Place the bean leaflets, one from the open and one from the shade, upon a slip of clean glass in a photographer's printing frame, and over the two specimens lay a sheet of sensitized paper, and expose them to the sun. When the work is done you will have a print of each, but the thinner one from the shade will have recorded the fact in the darker print. In short, the sun will have made its own registration of its own penetrability.

Nothing that has been named in the way of apparatus is expensive in the ordinary sense. Anyone who can afford to

have a bicycle and keep it in repair is able to follow up the suggestions. That a child of nine years can be interested in this study of plants is certain, for it has been tested by the writer to his entire satisfaction.

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